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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

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Method of generating a 3-dimensional effect

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Method of Generating a 3-Dimensional Effect

Method of Generating a 3-Dimensional Effect

Field of the Invention

The invention relates to a method for generating a 3-dimensional effect, to a 3-dimensional image produced by said method, their use for decorative and security applications and to security markings and documents of value comprising such a 3-dimensional image.

Background and Prior Art

The generation of 3-dimensional effects based upon the projection of two different perspective images being viewed in the left and right eyes is known in prior art. Typically two images of the same object are prepared with a small change in the visual perspective of the image. These images are then viewed in such a manner that each eye of the observer only sees one of the images. The visual process then interprets the two separate images as a single 3-dimensional image. This can be achieved in a variety of manners.

Steroscopic viewers require the use of two distinct images which are viewed through two distinct optical paths.

Composite images can be prepared by superimposing the two separate images using two different coloured inks, e.g. red and blue. When viewed through a device containing suitable red and blue filters each eye only sees one of the component images and reconstructs the 3-D image.

The two images can be projected onto a screen using polarised (linear or circular) light. Again, suitable viewing devices enable the viewer to reconstruct the 3-D image. Many devices are described as LCD shutter devices. These use liquid crystalline materials to provide a filter to each eye. The device is electronically controlled so that the shutters are activated sequentially. This allows the viewer to see first

one image through the left eye and later the other image through the right eye.

The idea of using cholesteric liquid crystal (CLC) based pigments to generate these effects is described in WO 99/02340. The pigments described have a changing helical pitch which makes them reflective in a wide range of wavelengths. They comprise a bilayer of polymerized CLC material, wherein each layer exhibits a non-linear pitch distribution throughout its thickness direction and as a result shows reflection of a broad wavelength band with asymmetrical reflection characteristics. The pitch gradient is achieved by mixing together a polymerizable CLC material and a non-polymerizable nematic LC material, coating the mixture onto a substrate, annealing to achieve planar alignment and curing e.g. by UV irradiation. Upon curing phase segregation of the non-polymerizable nematic LC material and the polymerized CLC material occurs. This leads to a pitch distribution including regions with high pitch and regions with low pitch within the material. The bilayer is then prepared by laminating together two similar single CLC layers with non-linear pitch distribution and asymmetrical reflection characteristics in such a manner that the resulting bilayer has symmetrical reflection characteristics. The pigments can be prepared in both right and left handed forms which means that they reflect right or left handed circularly polarised light respectively. Also described is a system whereby the composite image is viewed through a filtering device manufactured from similar broad band cholesteric liquid crystal materials.

WO 96/10208 describes the generation of images utilising CLC materials by interlacing two images in an array form on a polarisation encoded medium.

US 5,692,226 discloses a technique for securing motion pictures by generating two images of differing polarisation using CLCs.

US 5,457,554 describes a 3D-image comprising two images of left- and right-handed CLC inks comprising solid CLC platelets or flakes.

US 5,398,131 relates to a stereoscopic image with left- and right-handed LC inks, which may comprise e.g. encapsulated CLC materials. Further described are inks comprising crosslinkable CLC silicones that are oriented at high temperatures of 60-90°C and made into solid films by thermal curing or photocuring.

However, the methods described in prior art have several drawbacks. The CLC pigments and flakes described in WO 99/02340 and US 5,457,554 require a complicated production process. The methods and apparatus described in WO 96/10208 and US 5,692,226 require complicated arrangements of optical components and multiplexing or patterning techniques. The method described in US 5,398,131 requires the CLC inks to be mixed or superimposed to form a stereo pair of images and, where curable materials are involved, requires high processing temperatures.

It was an aim of the present invention to provide new methods for generating 3-dimensional effects and images that do not have the drawbacks of prior art. Another aim was to provide methods that do not need complicated arrangements of optical elements and do not need materials the preparation of which requires a large number of process steps and unfavourable reaction conditions. Further aims of the invention are immediately evident to the skilled in the art from the following description.

The inventors have discovered that 3-dimensional effects can be obtained without the use of flaked LC pigment materials. Two-stage printing or coating and UV curing of reactive CLC materials can be carried out at low temperatures below 60°C or even at RT as described below to form the two different perspective images required for 3-D imaging. This does not require the formation of variable-pitch LC flakes and can be viewed with standard circular

polariser devices, provided that each eye sees the image through only one of the circular polarisers.

Furthermore, the inventors have found that complicated images of CLC flakes are not required to provide a perception of depth in an image. By utilising both enantiomeric forms of CLC materials in a printed/coated design an impression of depth is obtained, even when the two enantiomeric forms are printed into different regions or form different images, when viewed through a viewing device comprising two circular polarisers, provided that the handedness of each polariser is different and that each eye can only see the image through one of the polarisers. The circular polarisers necessary for this viewing device need not be manufactured from similar liquid crystalline materials but standard circular polarisers may be used.

This effect can be seen from a distance of several metres and when combined with other properties of CLC materials such as angular colour dependency and thermochromism imparts an additional security feature. An advantage of this kind of device as a security feature is that the effect is destroyed if the feature is covered with material such as adhesive tape or clear polymer films since it disturbs the polarisation state of the light.

Both these processes are described in more detail below.

Summary of the Invention

The invention relates to a method of generating a 3-dimensional effect by providing at least one first and at least one second image layer of a chiral liquid crystal material, wherein one of said first and second image layer reflects right-handed circularly polarised light and the other reflects left-handed circularly polarised light, characterized in that

said first and second image layer comprise polymerised or crosslinked cholesteric liquid crystal (CLC) material and are obtained by providing a polymerisable CLC material on a

substrate, aligning said material into planar orientation and polymerising said material in its liquid crystal state at temperatures below 60 °C, and/or

- the first and second image are not directly superimposed onto each other and/or do not form a stereo pair of images.

The invention further relates to an apparatus for generating a 3-dimensional effect comprising at least one first and at least one second image layer as described above and below.

The invention further relates to a 3-dimensional image generated by a method or an apparatus as described above and below.

The invention further relates to the use of a method, apparatus or image as described above and below for decorative or security applications.

The invention further relates to a security or verification marking or device comprising an apparatus or image as described above and below.

The invention further relates to a security device comprising a printed area containing both enantiomeric forms of a chiral liquid crystal material that can verified from large distances by viewing through a device made from two circular polarisers, one of which is left handed and the other is right handed.

The invention further relates to a document of value comprising a security or verification marking or device as described above and below.

Detailed Description of the Invention

A first preferred embodiment of the present invention relates to a method of generating a 3-dimensional effect by providing at least one first and at least one second image layer of a chiral liquid crystal

material, wherein one of said first and second image layer reflects right-handed circularly polarised light and the other reflects left-handed circularly polarised light, characterized in that said first and second image layer comprise polymerised or crosslinked CLC material, and are obtained by providing a polymerisable CLC material on a substrate, aligning it into planar orientation and polymerising it in its liquid crystal state at temperatures below 60°C.

By utilising this method, a 3-dimensional effect can easily be obtained without the use of flaked LC pigment materials or complicated manufacturing or assembling techniques. The images can be provided by two-stage printing or coating and UV curing of a reactive chiral LC materials to form the two different perspective images required for 3-D imaging. The image can be viewed with standard circular polariser devices, provided that each eye sees the image through only one of the circular polarisers.

Especially suitable materials are polymerisable CLC mixtures comprising one or more achiral polymerisable mesogenic compounds and one or more polymerisable or non-reactive chiral mesogenic dopants. Suitable and preferred polymerisable CLC mixtures are disclosed for example in EP 1 134 596 A, GB 2 357 291 A, GB 2 315 760 A, US 6,117,920 and EP 0 880 570 A, the entire disclosure of which is incorporated into this application by reference. The process of coating, aligning and polymerising the polymerisable CLC material to form the image layers can be carried out by standard techniques which are known in the art and is also described in the above mentioned documents.

Especially preferred variants of said first preferred embodiment are the following

- the polymerisable CLC material comprises at least one achiral polymerisable mesogenic compound and at least one chiral compound which may in addition be polymerisable and/or mesogenic.

the CLC material is polymerised at a temperature from 30 to 50°C, preferably at a temperature from 30 to 40°C, in particular from 30 to 35°C.

- the CLC material is polymerised at a temperature from 10 to 30°C, preferably at room temperature.
- said first and second image layer are obtainable by coating or printing a layer of polymerisable CLC material onto the same side or onto opposite sides of a substrate, orienting the material, polymerising the material and optionally removing the substrate from the polymerised layers.
- said first and second image layer reflect circularly polarised light of different wavelengths.
- said first image layer is provided on a substrate and optionally covered by an intermediate layer, and said second image layer is provided on top of said first image layer.
- said substrate comprises a light absorbing material.
- at least one quarter wave retardation layer is provided on top of said first or second image, in this case the images are best observed through a linear polariser.

A second preferred embodment of the present invention relates to a method of generating a 3-dimensional effect by providing at least one first and at least one second image layer of a chiral liquid crystal material, wherein one of said first and second image layer reflects right-handed circularly polarised light and the other reflects left-handed circularly polarised light, characterized in that the first and second image are not directly superimposed onto each other and/or do not form a stereo pair of identical images.

Especially preferred is a method as described above wherein the first and second image are not directly superimposed onto each other and do not form a stereo pair of images.

The inventors have found that complicated images of CLC materials are not required to provide a perception of depth in an image. By utilising both enantiomeric forms of CLC materials in a printed/coated

design an impression of depth is obtained, even when the two enantiomeric forms are printed into different regions or form different images, when viewed through a viewing device comprising two circular polarisers, provided that the handedness of each polariser is different and that each eye can only see the image through one of the polarisers. The circular polarisers necessary for this viewing device need not be manufactured from similar liquid crystalline materials but standard circular polarisers may be used.

This effect can be seen from a distance of several metres and when combined with other properties of CLC materials such as angular colour dependency and thermochromism imparts an additional security feature. An advantage of this kind of device as a security feature is that the effect is destroyed if the feature is covered with material such as adhesive tape or clear polymer films since it disturbs the polarisation state of the light.

The CLC materials can be applied by conventional printing and coating processes. It is possible to use pure CLC materials, encapsulated CLCs, solutions of CLCs in a solvent or polymerised or crosslinked CLC materials like those described in the first preferred embodiment above.

Especially preferred are encapsulated CLC materials. Especially suitable are thermochromic CLC mixtures like for example those disclosed in GB 2 355 987 and GB 2 280 681. However, generally any chiral LC materials can be used provided that similar mixtures can be prepared with both chiralities of material. Suitable encapsulation methods and materials are known in the art and are also described in the above mentioned documents.

Further preferred are polymerised CLC materials. For example, suitable polymerisable CLC materials are disclosed in EP 1 134 596 A, GB 2 357 291 A, GB 2 315 760 A, US 6,117,920 and EP 0 880 570 A, the entire disclosure of which is incorporated into this application by reference. These materials can be aligned and

polymerised to form polymerised CLC image layers by standard techniques that are known in the art and are also described in the above documents.

Especially preferred variants of said second preferred embodiment are the following

- said first and second image layer comprise are obtained from a polymerisable CLC material comprising at least one achiral polymerisable mesogenic compound and at least one chiral compound which may in addition be polymerisable and/or mesogenic
- said first and second image layer are obtainable by coating or printing a layer of polymerisable CLC material onto a substrate, orienting the material, polymerising the material and optionally removing the substrate from the polymerised layers.
- said first and second image layer reflect circularly polarised light of different wavelengths.
- said substrate comprises a light absorbing material.
- at least one quarter wave retardation layer is provided on top of said first or second image, in this case the images are best observed through a linear polariser.

Another object of the invention is an apparatus for generating a 3-dimensional effect comprising at least one first and at least one second image layer as described above and below.

Especially preferred is an apparatus that further comprises a means of detecting the 3-dimensional effect comprising a pair of films, foils, lenses or glasses, one of which transmits the right-handed circularly polarized light and the other transmits the left-handed polarized light reflected by said first and second image layer.

The method, apparatus and image as described above and below are preferably used for decorative or security applications. Thus, another object of the invention is a security or verification marking,

device or thread comprising an apparatus or image as described above and below.

The security marking can be used for direct application e.g. onto an article, device or document, or as threads, holograms or hot stamping foils for decorative or security applications, to authenticate and prevent counterfeiting of documents of value, for identification of hidden images, informations or patterns. It can be applied to consumer products or household objects, car bodies, foils, packing materials, clothes or woven fabric, incorporated into plastic, or applied as security markings or threads on documents of value like banknotes, credit cards or ID cards, national ID documents, licenses or any product with money value, like stamps, tickets, shares, cheques etc..

Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilise the present invention to ist fullest extent. The following examples are, therefore, to be construed as merely illustrative and not limitative of the remainder of the disclosure in any way whatsoever.

In the foregoing and in the following examples, unless otherwise indicated, all temperatures are set forth uncorrected in degrees Celsius and all parts and percentages are by weight.

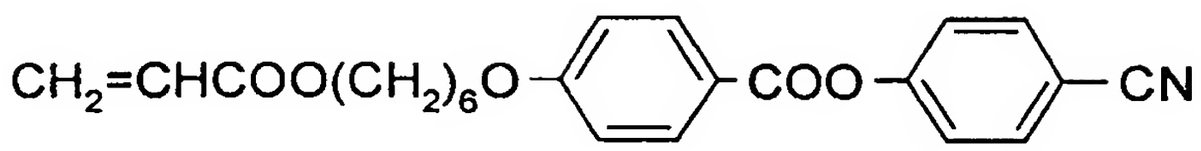
Example 1

3-D imaging process utilising polymerised liquid crystal material

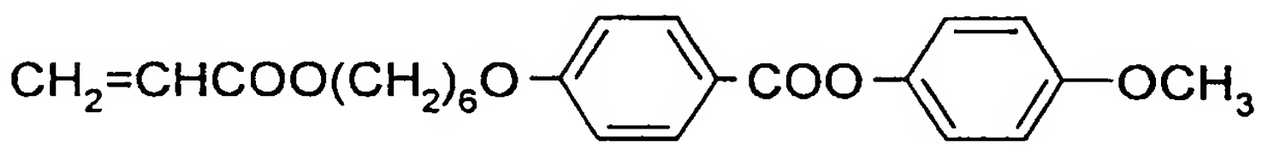
A polymerisable liquid crystal mixture was prepared as follows:

Compound (A)	10.24 %
Compound (B)	8.18 %
Compound (C)	1.58 %
Compound (D)	9.92 %
Irgacure 369	2.62 %

Fluorad FC 171	0.12 %
Xylene	67.34 %



(A)



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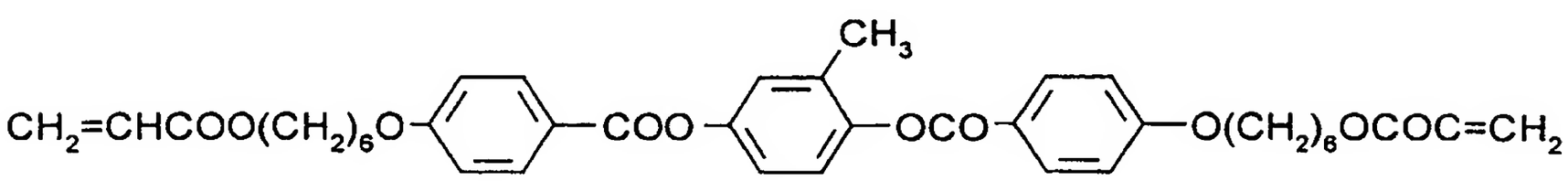

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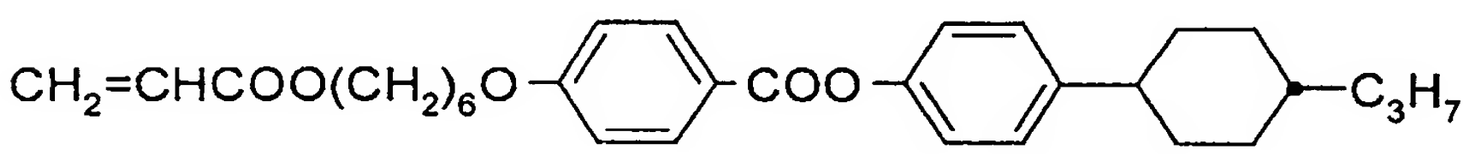
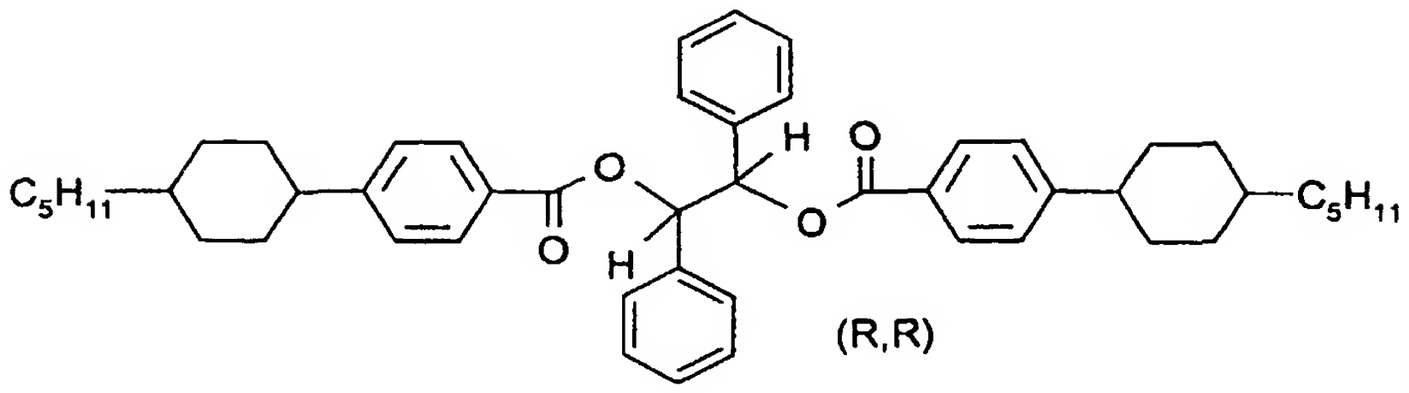


(D)

Compounds (A), (B) and (C) can be prepared according to or in analogy to the methods described in D.J.Broer et al., Makromol. Chem. **190**, 3201-3215 (1989). Compound (D) and its preparation are described in GB 2,280,445. Irgacure 369 is a commercially available photoinitiator (Ciba Geigy). Fluorad FC 171 is a commercially available surfactant (3M Inc.).

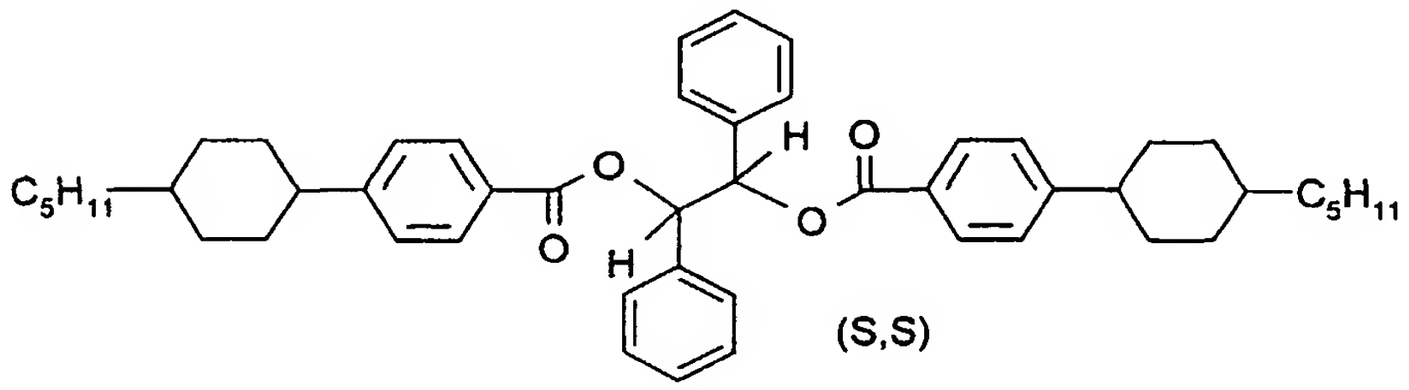
This mixture was split into two equal parts and the chiral compound (E1) and (E2), respectively, was added in an amount of 5 % by weight of the total amount of solid components, to impart the required reflected colour properties. This yielded Mixture 1 and 2 as described below:

Mixture 1: Host + Compound (E1) (5% by weight of total solids)
Mixture 2: Host + Compound (E2) (5% by weight of total solids)



(R,R)

(E1)



(S,S)

(E2)

The preparation of (E1) and (E2) is described in GB 2,328,207.

The solution of Mixture 1 in xylene was coated onto a 30 micron thick TAC (Triacetylcellulose) film. The coating was exposed to UV radiation at a temperature of 30-35°C through a mask. This had the effect of fixing the colour in the areas that were exposed to the UV radiation. The uncured material was washed off using isopropanol.

The solution of Mixture 2 in xylene was then coated onto the reverse side of the TAC film. The mixture was allowed to align and then cured as described above through a different mask. Again the uncured material was washed off using isopropanol.

When viewed through a left handed circular polariser the image depicted in Figure 1 is seen and when viewed through a RHCP the image depicted in Figure 2 is seen. If a viewer is prepared such that the LHCP covers the left eye and a RHCP covers the right eye a perceived depth appears to the printed image. This effect is discernible from a relatively large distance.

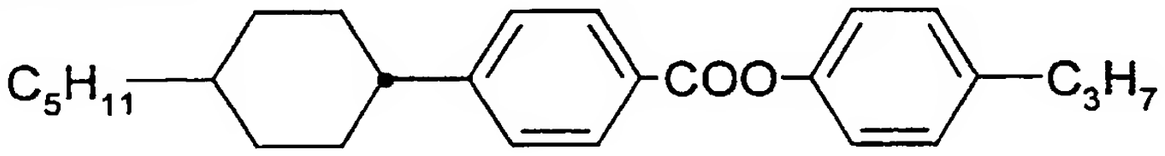
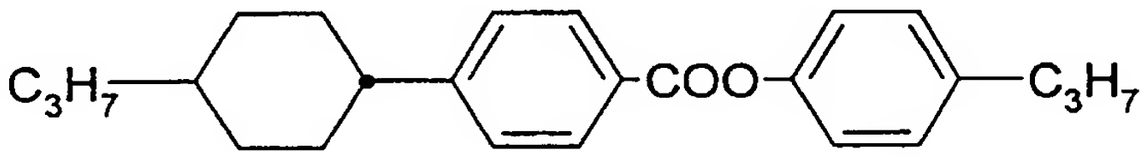
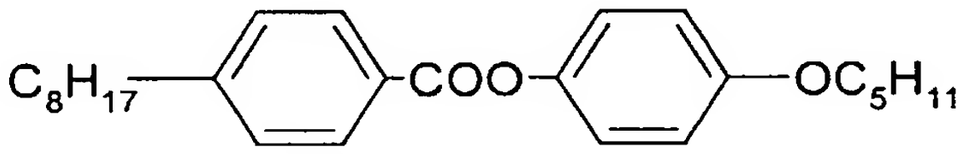
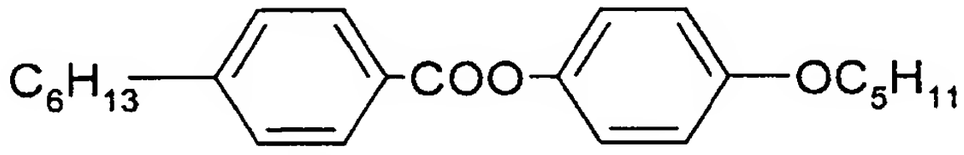
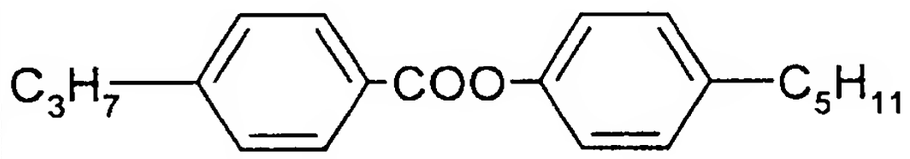
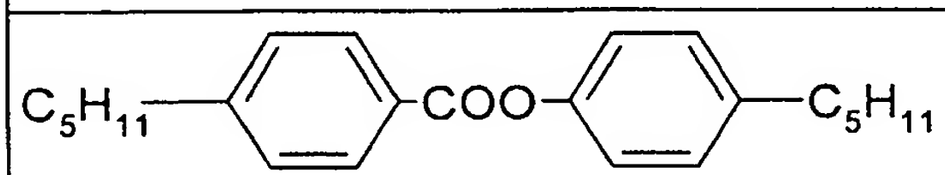
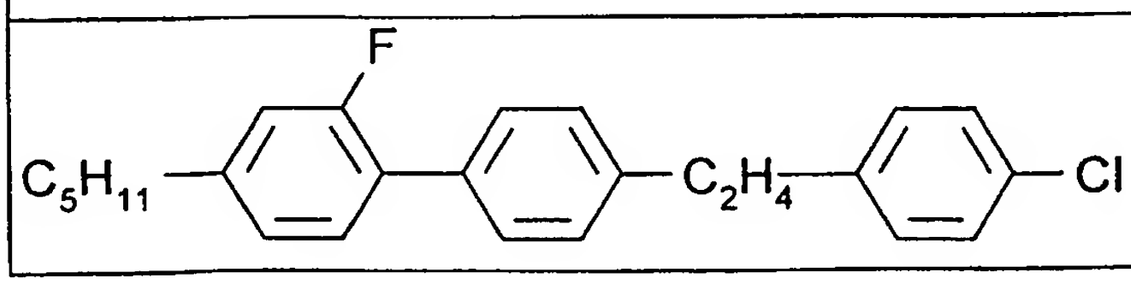
Alternatively the coatings could be prepared by sequential coating onto a single film, preferably a black film to absorb light.

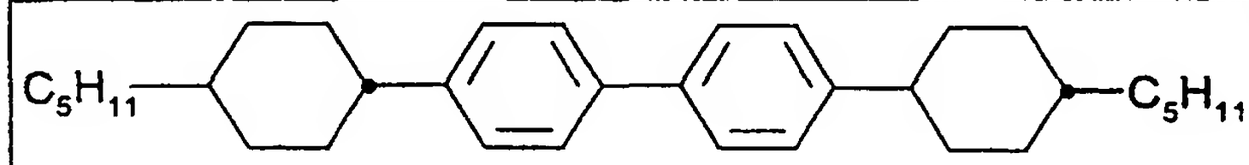
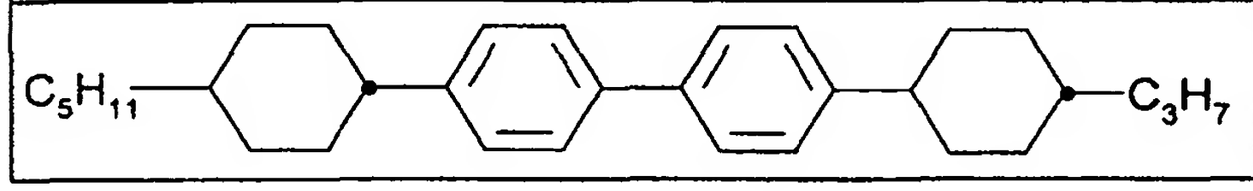
Alternatively the two images may be sequentially printed, with a curing process to fix the first image before the second image is applied.

Example 2

Perceived Depth process

A nematic liquid crystal host mixture is prepared as below.

Material	%
	8.01%
	3.43%
	14.85%
	14.86%
	11.44%
	29.13%
	13.72%

	2.28%
	2.28%

Chiral dopants are added to this host to prepare two mixtures that have the same reflection colour and differ only in their chirality.

HOST	87.09%
S811	2.77%
S2011	5.23%
E1	4.91%

HOST	87.09%
R811	2.77%
R2011	5.23%
E2	4.91%

R/S-811 and R/S-2011 are commercially available chiral dopants (from Merck KGaA, Darmstadt, Germany).

These mixtures are then encapsulated and the capsules formed into an ink system. The inks are printed by screen printing techniques to produce the design as schematically depicted in Figure 3, wherein the "R" is printed in the opposite chirality from the other letters.

When viewed through a viewing device comprising a left handed and a right handed circular polariser, such that each eye only sees the image through one polariser a perceived depth is seen in the image. The "R" seems to have be at another distance than the remaining letters. This effect can be seen from a distance of several metres.

Both the above examples can be modified by the inclusion of a quarter-wave retardation layer. This allows the effects to be seen through a device containing linear polarisers. Effectively the circular polariser comprises a quarter-wave layer and a linear polariser, the relative distance between these two layers is not important.

Patent Claims

1. Method of generating a 3-dimensional effect by providing at least one first and at least one second image layer of a chiral liquid crystal material, wherein one of said first and second image layers reflects right-handed circularly polarised light and the other reflects left-handed circularly polarised light, characterized in that

said first and second image layer comprise polymerised or crosslinked cholesteric liquid crystal material and are obtained by providing a polymerisable chiral liquid crystal material on a substrate, aligning said material into planar orientation and polymerising said material in its liquid crystal state at temperatures below 60°C, and/or

said first and second image layers are not directly superimposed onto each other and/or do not form a stereo pair of images.

2. Method according to claim 1, wherein said first and second image layer comprise polymerised or crosslinked cholesteric liquid crystal material and are obtained by providing a polymerisable chiral liquid crystal material on a substrate, aligning said material into planar orientation and polymerising said material in its liquid crystal state at temperatures below 60°C.

3. Method according to claim 2, wherein the polymerisable chiral liquid crystal material comprises at least one achiral polymerisable mesogenic compound and at least one chiral compound which may in addition be polymerisable and/or mesogenic.

4. Method according to claim 2 or 3, wherein said first and second image layer are obtainable by coating or printing a layer of

polymerisable chiral liquid crystal material onto the same side or onto opposite sides of a substrate, orienting the material, polymerising the material and optionally removing the substrate from the polymerised layers.

5. Method according to claim 1, wherein said first and second image layer comprise encapsulated cholesteric liquid crystal material.

6. Method according to claim 1, wherein said first and second image layer comprise polymerised cholesteric liquid crystal material.

7. Method according to at least one of claims 1 to 6, wherein said first and second image layer reflect circularly polarised light of different wavelengths.

8. Method according to at least one of claims 1 to 7, wherein said first image layer is provided on a substrate and optionally covered by an intermediate layer, and said second image layer is provided on top of said first image layer.

9. Method according to claim 8, wherein said substrate comprises a light absorbing material.

10. Apparatus for generating a 3-dimensional effect comprising at least one first and at least one second image layer as defined in at least one of claims 1 to 9.

11. Apparatus according to claim 10, further comprising a means of detecting the 3-dimensional effect comprising a pair of films, foils, lenses or glasses, one of which transmits the right-handed circularly polarized light and the other transmits the left-handed polarized light reflected by said first and second image layer.

12. 3-dimensional image generated by a method or an apparatus according to at least one of claims 1 to 11.

13. Use of a method, apparatus or image according to at least one of claims 1 to 12 for decorative or security applications.

14. Security or verification marking or device comprising an apparatus or image according to at least one of claims 10 to 12.

15. Security device comprising a printed area containing both enantiomeric forms of a chiral liquid crystal material that can verified from large distances by viewing through a device made from two circular polarisers, one of which is left handed and the other is right handed.

16. Document of value comprising a security or verification marking or device according to claim 14 or 15.

Abstract of the Disclosure

The invention relates to a method for generating a 3-dimensional effect, to a 3-dimensional image produced by said method, their use for decorative and security applications and to security markings and documents of value comprising such a 3-dimensional image.

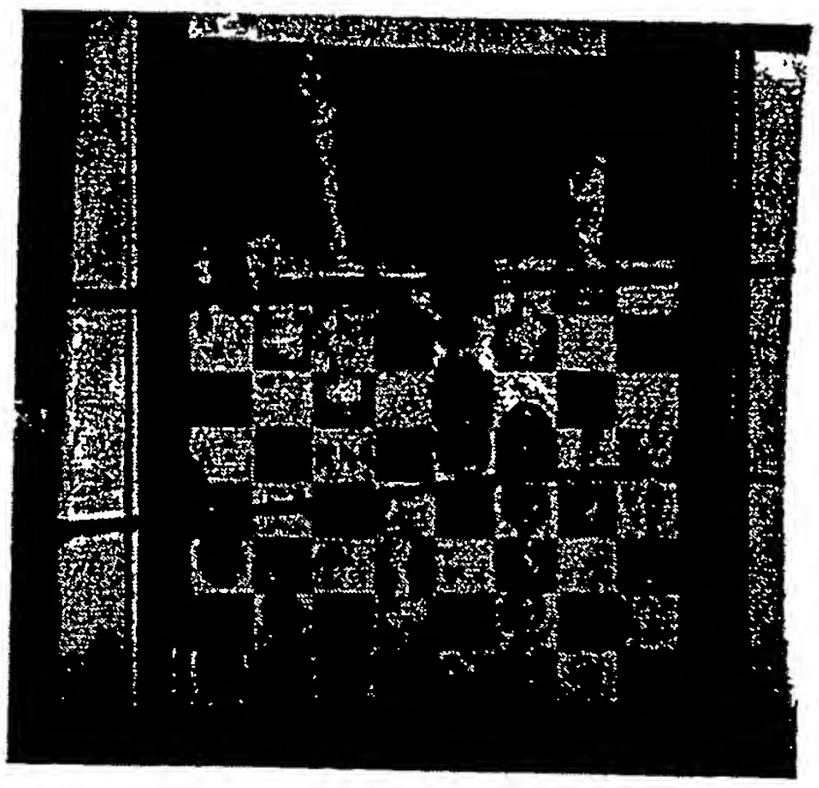


Figure 1

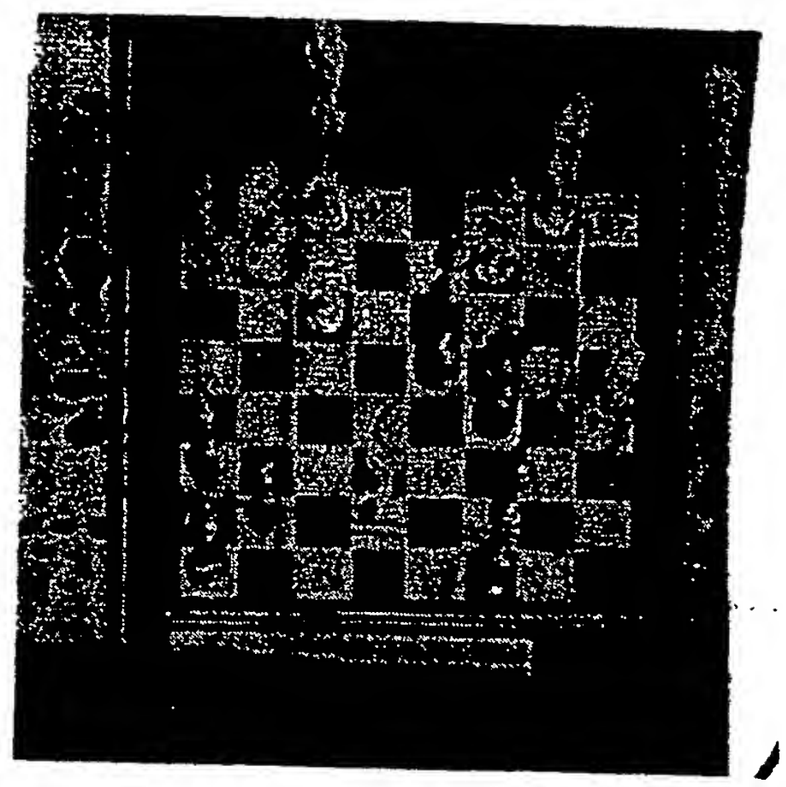


Figure 2

MERCK

Figure 3